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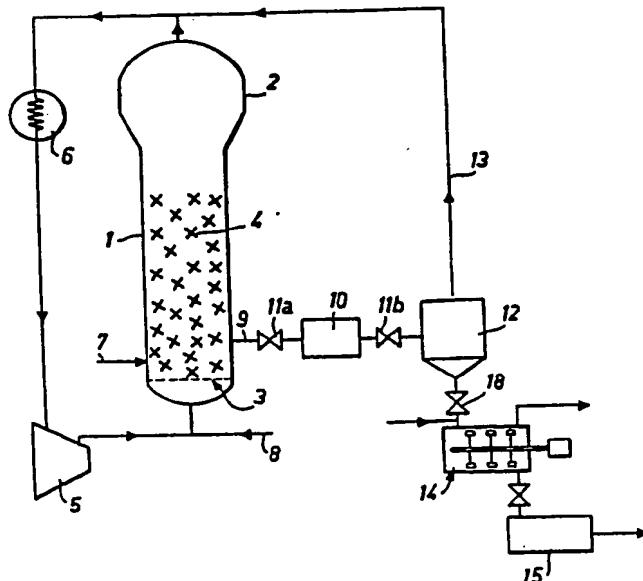
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### ④ Apparatus for degassing and pelletizing polyolefins.

⑤ The invention relates to a process and a device for degassing and converting into pellets polyolefins from a gas-phase reactor.

A device according to the invention comprises, in combination (fig. 1):

- a reactor (1) for the catalytic polymerisation in the gas phase of alpha-olefins, equipped with a polyolefin outlet (9);
- a device (12) for primary degassing by separation of the solid and gas phases, connected to the said outlet;
- a device for secondary degassing (14) to substantially free the particles of the gases accompanying them and which is connected to the outlet of the primary degassing (12) and which comprises a mechanical stirrer (14a) making it possible to raise the temperature of the particles to a temperature close to the minimum sintering temperature by conversion of the mechanical energy into heat;
- and a device (15) for pelletizing the particles by extrusion through a die, this device being connected to the outlet of the said secondary degassing device.



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APPARATUS FOR DEGASSING AND PELLETING POLYOLEFINS

The present invention relates to a process and to a device for degassing and directly converting into pellets particles of polyolefins leaving a gas-phase polymerisation reactor. More especially the invention relates to the production of polymers or 5 copolymers of alpha-olefins particularly polyethylene and copolymers of ethylene and of higher alpha-olefins having from 3 to 12 carbon atoms, by catalytic polymerisation at low pressure in the gas phase, either in a stirred apparatus where the particles of polymer are maintained in suspension by mechanical agitation, or in a 10 fluidised-bed reactor.

The polymer or copolymer produced in the stirred apparatus or in the fluidised bed reactor may be withdrawn by a continuous or discontinuous process. During the withdrawal, a part of the gaseous atmosphere accompanies the solid product. For reasons of process 15 economy, the products withdrawn pass into a primary degasser which makes it possible to separate on the one hand the solid products and on the other hand a gas phase rich in monomer, which is recycled into the reactor. The powder leaving the primary degasser is accompanied by a small quantity of process gas, in particular by gas 20 occluded in the pores of the solid particles. The powder is then generally cooled and stored in silos, in which the accompanying gases are liable to diffuse slowly out of the particles and the content of hydrocarbon in the atmosphere of the silos or in their vicinity may become excessive having regard to the safety standards 25 for human beings, or even involve risk of explosion. Likewise,

these gases are freed during the pelleting of the particles and may cause difficulties at this stage.

To avoid these problems, in the processes known to date, the particles leaving the primary degassing undergo a secondary 5 degassing before being stored. This degassing is accomplished, for example, by bringing the solid particles into contact with a cold gas stream of air or nitrogen for a period of the order of 5 to 30 minutes.

During this operation the polymer powder cools on contact with 10 the cold gas. This cooling is harmful to the economics of the process when, as is very often the case, the subsequent operation is a pelleting of the particles by passage through an extruder which demands re-heating of the polymer close to its melting temperature. Moreover, the cooling of the powder makes more difficult the 15 separation of the gas from the particles in which it is included.

One object of the present invention is to provide means making it possible to effect good secondary degassing of the hot polyolefin particles leaving a primary degasser and to convert directly these particles into pellets without storing the polymer in an 20 intermediate silo.

Another object of the invention is to provide means making it possible to effect a good secondary degassing of polyolefin particles which have to undergo a subsequent pelleting treatment by extrusion, in such a way that the particles leave the secondary 25 degasser at a relatively high temperature and enter the extruder at this temperature, so that the utilisation of energy necessary for the pelleting is reduced.

It has been described in DE 3108093 (Berstorff Maschinen) a method for pelleting particles of a polymer, such as a polyethylene, 30 produced in a gas-phase polymerisation reactor. A mixture of the polymer and of the gas present in the polymerisation reactor is withdrawn from the latter through a lock chamber and is introduced into a cyclone in which the polymer is partly degassed. The gas which separates is recycled into the polymerisation reactor, whereas 35 the solid polymer particles are introduced into a vertical mixer

wherein it is transformed into a plastic mass which is introduced into the inlet of a pelleting machine. According to DE 3108093 the advantage of the method is that the plasticised polymer mass acts as a sealant which prohibits that outside gas, such as air, could enter

5 into the pelleting machine. As a result, however, the polymer cannot be degassed before entering the pelleting equipment, and gas containing monomer is freed from the polymer during the pelleting operation, which is extremely hazardous and involve high risk of explosion.

10 European patent application EP-A-0006288 (Imperial Chemical Industries) describes a process and an apparatus for separating olefin monomer from a solid particulate polymer, especially polypropylene obtained by a gas phase polymerisation. A mixture of the polymer and of the gas present in the polymerisation reactor is

15 introduced into a cyclone wherein the polymer is partly degassed. Before being exposed to the atmosphere the polymer is then subjected to mechanical agitation until the temperature of the polymer attains at least 90°C, whereas the released olefin monomer is separated from the polymer and recycled to the polymerisation reactor. The

20 treatment is performed in the absence of oxygen and preferably in the absence of any gas stream which would dilute the recovered monomer.

The object of the process described in this patent application is to recover non-polymerised gases rich in monomers to recycle them

25 into the reactor. The degassed solid products are sent into a storage vessel or into a device where they undergo a treatment intended to eliminate the catalyst residues.

Devices referred to as finishers are known which are mechanical agitators employed to modify the physical state of particles of

30 thermoplastic resins in order to improve their flowability and their bulk density. These finishers are produced in particular by WEDCO Inc and they are described for example in US Patent 3229002 and FR-A-2160434 belonging to the said company.

US 3229002 describes an application of the finishers to resins

35 pulverised in a pulverising equipment for obtaining a finely divided

powder, having therefore a poor flowability.

Patent FR-A-2160434 describes an application of the finishers to particles of thermoplastic resin in order to add to these a coloured pigment or any other charge in the finely divided state.

5 These prior patents relate to applications concerning powders which have been previously freed from the major part of the occluded gases.

The published patent application GB-2077272B (Asahi Kasei) describes a process intended to increase the size of the particles.

10 According to this process the particles are preheated, then subjected to a mechanical agitation in a high-speed rotary mechanical stirrer equipped with a heating jacket, for example, a stirrer of the "Henschel" type. The particles are brought to the temperature of mutual adhesion, that is to say a temperature which 15 is at least the initial melting temperature and which can be 20°C higher than the melting point of the resin. The powder leaving the stirrer is cooled by agitation in a current of cold air.

This prior patent describes a treatment of the particles of polyolefins by mechanical agitation and heating of the particles, 20 but it does not teach or suggest that the particles can be degassed by such a mechanical treatment. Moreover, the aim of the treatment described is to eliminate pelletting and the particles are cooled at the outlet from this stirrer.

The process according to the invention is intended to convert 25 into pellets polyolefin particles which have been produced in a gas-phase catalytic polymerisation reactor and which have undergone a primary degassing at the outlet from the said reactor, but which still contain occluded gases from which they must be freed before they are extruded.

30 The objectives of the invention are achieved by a process according to which the particles leaving the primary degasser are introduced into a secondary degassing device equipped with a mechanical stirrer in which they are agitated for a period such that the particles are brought by mechanical agitation to a temperature 35 close to the minimum sintering temperature, so that they are

substantially freed from the gases accompanying them, and the hot particles leaving the said mechanical stirrer are introduced into the extruder of a pelleting unit.

5 The temperature at which the particles are brought by mechanical agitation is suitably close to the minimum sintering temperature and is preferably comprised between  $T_s - 5^\circ\text{C}$  and  $T_s + 5^\circ\text{C}$ , more especially between  $T_s - 2^\circ\text{C}$  and  $T_s + 2^\circ\text{C}$ ,  $T_s$  being the minimum sintering temperature of the particles.

10 Preferably the secondary degassing is performed in the presence of a gas stream introduced into the secondary degasser. This gas stream advantageously consists of an inert gas such as nitrogen. It may also consist of a gas containing oxygen and/or water vapour which inactivate the constituents of the polymerisation catalyst.

15 The device according to the invention for degassing and converting into pellets polyolefin particles produced in a gas-phase catalytic polymerisation reactor for alpha-olefins equipped with a polyolefin outlet comprises, in combination:

- a device for primary degassing by separating the solid and gas phases which is connected to the said outlet;
- a secondary degassing device to free substantially the particles from the gases accompanying them, and which is connected to the outlet of the said primary degassing and which comprises a mechanical stirrer making it possible to raise the temperature of the particles to a temperature close to the minimum sintering temperature by converting the mechanical energy into heat
- and a device for pelleting the particles by extrusion through a die, this device being connected to the outlet of the said secondary degassing device.

30 According to a preferred mode of embodiment, the secondary degassing device comprises of cylindrical chamber with a horizontal axis having a particle inlet which is connected to the outlet of the primary degasser and a particle outlet which is connected to the particle pelleting device, which chamber is provided with a horizontal shaft carrying stirrer blades and which 35 is rotated by a motor.

The residence time of the particles in the said chamber and the speed of rotation of the shaft can be set so that the particles are brought by mechanical agitation to a temperature close to the minimum sintering temperature of the polyolefin particles.

5 The secondary degassing of the particles by means of a mechanical stirrer which heats the particles solely by the conversion of mechanical energy into heat, makes it possible to attain and even slightly to exceed the minimum sintering temperature without creating hot spots inside the mass of particles and without  
10 10 the particles forming conglomerates.

It is known that the high temperature favours the exit of the gases occluded in the pores of the particles, and the process according to the invention, which makes it possible to bring the particles to a temperature as high as possible without creating a  
15 15 conglomerate of adhering particles, permits of obtaining a very good secondary degassing.

A secondary degassing device according to the invention permits of feeding the pelleting device with hot degassed particles, so that the energy consumed by the extruder to melt the particles is  
20 20 reduced. A large part of the mechanical energy utilised for the secondary degassing is saved.

The process and the secondary degassing device according to the invention make it possible to free the polyolefin particles from the occluded gases without any unfavourable thermal effect.

25 The following description relates to the attached drawings which represent an example of a working device according to the invention, whilst not having a restrictive character.

Figure 1 represents in diagram form an assembly of a device for the polymerisation or copolymerisation of olefins in the gas phase  
30 30 and for pelleting the polyolefins.

Figure 2 represents an axial section through a mechanical stirrer device applicable to the invention.

Figure 1 represents a reactor for polymerisation of olefins in the gas phase in a fluidised bed. This type of reactor is well  
35 35 known and it is pointless to describe it in detail. One may point

out merely that it comprises a vertical cylindrical chamber (1) which has a widening (2) at the top. It comprises a fluidisation grid (3) above which there is a fluidised bed (4), consisting of polyolefin particles in the course of polymerisation which are 5 maintained in the state of a fluidised bed by a rising gas stream. The hot gases leaving the top of the reactor are taken up by a blower (5) which delivers them to the base of the reactor.

The recycled gases pass into a cooler (6). The chamber (1) comprises a catalyst inlet (7) and an inlet (8) for monomeric 10 olefins. It comprises an outlet (9) for withdrawal of polymer particles.

By way of illustration figure 1 represents a fluidised-bed reactor for the catalytic polymerisation of olefins in the gas phase, but it is specified that this reactor could also be a reactor 15 in which the particles are maintained in suspension by mechanical agitation.

The polyolefins produced by the reactor are withdrawn via the outlet (9) continuously or intermittently.

In the mode of embodiment represented in figure 1, the 20 withdrawal point (9) is equipped with a lock chamber (10) placed between two valves (11a) and (11b) activated alternately so that the withdrawal does not disturb the operation of the reactor. During the withdrawal a part of the gaseous atmosphere of the reactor 25 accompanies the solid polyolefin particles. The mixture of gas and of solid particles is treated in a primary degasser (12) which permits of separating the solid phase from a part of the gas phase accompanying the particles. The primary degasser (12) is, for example, a cyclone, but may be replaced by any other equivalent means of separation of gas from solid. The gases rich in non- 30 polymerised monomers are recycled into the reactor by a pipe (13).

An system according to the invention comprises a secondary degassing device (14) which is equipped with a mechanical stirrer (14a), which receives the solid particles leaving the primary degasser (12) and which frees them from the majority of gases 35 accompanying them by a process consisting in heating the particles

up to a temperature close to the minimum sintering temperature by mechanical stirring.

5 The hot, degassed particles leaving the secondary degassing device (14) are sent into a pelleting device (15) which comprises an extruder provided with an extrusion die and means for cutting the extruded filaments into pellets. The temperature of the particles entering the device (14) is generally comprised between 60° and 120°C.

10 The residence time of the particles in the device (14) and the rotation speed of the mechanical stirrer (14a) are set so that the particles are brought to a temperature close to the minimum sintering temperature of the particles. It is known that polyolefin particles do not have a precise melting temperature but that they can be characterised by a temperature, called minimum 15 sintering temperature, at which they begin to soften and have a tendency to stick together.

According to Peter Comso et al (Part. Charact./1984. pp 171-177) this minimum sintering temperature is the temperature at which a large drop in surface viscosity of the particles occurs. 20 Several methods have been recorded by the authors, for determining the minimum sintering temperature of the particles. A known method consists in performing fluidisation experiments using the particles and correlating the minimum fluidisation velocity as a function of temperature. At the minimum sintering temperature a discontinuity 25 appears in the correlation, as a result of the formation of agglomerates of particles. As a variant, it is possible to correlate the pressure drop in the fluidisation apparatus as a function of temperature, using a gas velocity slightly higher than the minimum fluidisation velocity; when sintering occurs, a sharp 30 decrease in pressure drop is observed. Another method proposed by the authors of the cited article consists in determining the elongation of a column of particles under a specific load as a function of the temperature. According to the nature of the polyolefin involved, the above mentioned methods indicate a minimum 35 sintering temperature varying within a range of a few degrees. Due

to this fact, it is recommended to determine the proper temperature condition in the device (14) itself, within a range of temperature of +5°C.

When sintering occurs, the particles of powder melt 5 superficially and it might be thought that this superficial melting would tend to prevent degassing. Experiments performed with a secondary degassing device according to the invention have shown that it was possible to reach and even slightly to exceed the minimum sintering temperature of the particles without their 10 sticking together and without the superficial melting of the particles preventing the occluded gases from leaving them, the mobility of the gases being improved by the increase in temperature.

In one system according to the invention for the production of polyethylene or copolymers of ethylene and higher alpha-olefins 15 containing from 3 to 12 carbon atoms, the operation of the mechanical stirrer (14) is set so that the temperature of the particles leaving the device (14) is comprised between 80°C and 120°C.

The heating up of the particles under the effect of the 20 mechanical energy of stirring makes it possible both to obtain better degassing by operating at the minimum sintering temperature and a considerable saving in energy, since the particles leaving the secondary degassing (14) are entered hot into the pelleting device (15) and the consumption of energy by this apparatus is consequently 25 substantially reduced.

Figure 2 is an axial section on a larger scale of a preferred mode of embodiment of the secondary degassing device (14).

The latter comprises a fixed cylindrical chamber with a horizontal axis (16) which is equipped with a particle inlet (17) 30 located at one end of the chamber near the upper generatrix. The inlet (17) is connected to the outlet of the primary degasser (12) via a valve (18) which makes it possible to break off the communication. The chamber (16) comprises an outlet (19) for the degassed solid particles which is located at the bottom of the tank, 35 at the end opposite the inlet (17). The outlet (19) is provided

with a motorised valve (20).

The chamber (16) comprises a mechanical stirrer (14a) which consists of a horizontal shaft (21), set in rotation by a motor (22) and carrying radial arms (23) the ends of which carry stirrer 5 blades (24).

According to the preferred mode of embodiment, the apparatus (14a) is a agitator of the WEDCO type, the blades of (24) of which have the shape of ploughshares. The shaft (21) carries at both its ends scraper blades (25a), (25b), which rub against the plain walls 10 (26a), (26b), closing the two ends of the cylindrical chamber (16).

The chamber (16) comprises another gas outlet (27) which is located at the end of the upper generatrix opposite the inlet (17) and which may be connected for example to a burner for gaseous effluents.

15 In order to faciliiate discharge of the gases, the chamber (16) may comprise means making it possible to circulate a scavenging gas in the chamber. These means consist for example of a pipe (28) which is connected to the inlet (17), into which an inert gas is passed, for example nitrogen. Advantageously the scavenging gas 20 contains oxygen and/or water vapour, so that it is possible to decompose the traces of residual catalyst contained in the polymer particles. The scavenging gas passes through the chamber, mixing with the gas extracted from the particles and entraining the latter towards the outlet (27).

25 The energy of mechanical stirring of the particles is converted into heat and the temperature of the particles leaving the chamber depends on the speed of rotation of the shaft (21) and the residence time of the particles in the chamber. It has been seen above that it was desirable to attain and even to exceed the minimum sintering 30 temperature of the polymer so as to improve the secondary degassing. It is therefore of interest to control the residence time of the particles in the chamber so as to regulate the temperature accurately. For this purpose the chamber comprises a temperature sensor (29) which is placed in the chamber, preferably 35 in the outlet (19). This sensor is connected to a temperature

regulator (30), either analog or digital, which compares the measured temperature against an adjustable reference value and which issues a command signal to the motorised valve (20), actioning this valve in the direction tending to nullify the difference between the 5 measured temperature and the reference value.

Tests have been performed by introducing 150 Kg/h of a high density ( $958 \text{ Kg m}^{-3}$ ) polyethylene powder into an apparatus such as that shown in figure 2, having a length of 105 cm and a diameter of 60cm. The mean residence time of the powder was 2 minutes and 30 10 seconds. The powder was introduced into the apparatus at  $80^\circ\text{C}$  and was raised to  $118^\circ\text{C}$ . No agglomerate of particles was observed. The content of non-polymerised hydrocarbons in the powder which was  $0.12 \text{ cm}^3$  of ethylene per gram of polymer was divided by 100. The powder leaving the apparatus was introduced into an extruder without 15 any special steps having to be taken.

In the normal degassing process, polyethylene leaves the secondary degasser at a temperature of  $40^\circ$  to  $50^\circ\text{C}$ , and the energy necessary to melt it in a pelleting device is of the order of 190 Wh/Kg. The energy to be fed to the pelletizer machine receiving 20 polyethylene leaving a degassing device according to the invention at a temperature of the order of  $118^\circ\text{C}$  is no more than 130 Wh/Kg, which is a very considerable saving with a better degassing result.

The experiment has been repeated with a copolymer of ethylene and of but-1-ene of 0.918 density, instead of high density 25 polyethylene. The temperature in the apparatus such as that shown in figure 2 was varied between  $95^\circ\text{C}$  and  $105^\circ\text{C}$ . The powder leaving the apparatus was introduced into an extruder without any problems occurring.

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Claims

1. Process for degassing and converting into pellets polyolefin particles which have undergone a primary degassing at the outlet of a reactor (1) for catalytic polymerisation in the gas phase, characterised in that the particles leaving the primary degasser (12) are introduced into a secondary degassing device (14) equipped with a mechanical stirrer (14a) in which they are agitated for a period such that the particles are brought by the mechanical agitation to a temperature close to the minimum sintering temperature, so that they are substantially freed from the gases accompanying them, and the hot particles leaving the said secondary degasser are introduced into the extruder of a pelleting unit (15).  
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2. Process according to Claim 1, characterised in that the residence time of the particles in the secondary degasser and the speed of rotation of the stirrer of this device are set in such a way that the particles are brought by the mechanical stirring to a temperature close to the minimum sintering temperature of the polyolefin particles.  
10
3. Process according to any of Claims 1 and 2, characterised in that an inert gas such as nitrogen is circulated in the said secondary degassing device (14), in order to facilitate the evacuation of the gases accompanying the polyolefin particles.  
15
4. Process according to any of Claims 1 to 3, characterised in that a gas containing oxygen and/or water vapour is circulated in the said secondary degassing device (14), in order to inactivate the constituents of the catalyst contained in the said polyolefin  
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- 25

particles.

5. Process according to any of claims 1 to 4, characterised in that the polyolefin particles are constituted of polyethylene or of copolymers of ethylene and of higher alpha-olefins having from 3 to 5 12 carbon atoms.

6. Device for degassing and converting into pellets polyolefin particles produced in a reactor (1) for the catalytic polymerisation in the gas phase of alpha-olefins, equipped with a polyolefin outlet (9), characterised in that it comprises in combination:

10 - a device (12) for primary degassing by separation of the solid and gas phases, connected to the said outlet (9);

- a secondary degassing device (14) to free substantially the particles from the gases accompanying them, which is connected to the outlet of the said primary degassing (12) and which

15 comprises a mechanical stirrer (14a) making it possible to raise the temperature of the particles to a temperature close to the minimum sintering temperature by converting the mechanical energy into heat;

- and a device (15) for pelleting particles by extrusion through

20 a die, this device being at the outlet from the said secondary degassing device.

7. Device according to Claim 6, characterised in that the said secondary degassing device comprises a cylindrical chamber with a horizontal axis (16) having a particle inlet (17) which is connected

25 to the outlet from the primary degasser (12) and a particle outlet (19) which is connected to the particle pelleting device (15), which chamber is provided with a horizontal shaft (21) bearing radial arms (23) equipped with stirrer blades (24) and which is set in rotation by a motor (22).

30 8. Device according to Claim 7, characterised in that the outlet orifice (19) for the degassed powder is equipped with a motorised valve (20) which is controlled by a temperature sensor (29) arranged in the said chamber upstream of the said valve.

9. Device according to any of Claims 6 to 8, characterised in that

35 it comprises means (27), (28) to evacuate the said gas mixed with

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the gas accompanying the polyolefin particles.

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